Clam Tissue Collection Report

Wyckoff/Eagle Harbor Superfund Site

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Contents

Figures

Tables

1.0 Background and Purpose

The purpose of the 2014 collection and analysis of clam tissue is to gather additional information necessary to evaluate whether natural recovery has resulted in a decrease in horse clam tissue chemical concentrations over time at the Eagle Harbor East Beach Operating Unit (OU) at Wyckoff, Washington. Clam tissue samples from East Beach and North Shoal sediments were first collected in 2003 for the 2002 OMMP Addendum (Integral Consulting, Inc 2004); clam tissue samples for the Intertidal Cap and West Beach locations were added in the 2011 and 2014 sampling events, respectively.

Tresus capax[1] (horse clam) spawns during the winter and therefore, the tissue lipid content is expected to be depleted during the January through March spawning time period. Since clams increase total lipids (where cPAHs would concentrate) with sexual maturation, spawning depletes the clam lipid reserves.[2] Sampling in May is therefore expected to represent clams with replenished lipid reserves. *T. capax* is a suspension/filter feeder eating diatoms, flagellates, dinoflagellates, and detritus. They are mature at three years with a shell length of approximately seven centimeters. The clam tissue data collected is used to document changes in tissue chemistry due to natural recovery at the site.

2.0 Methods

2.1 Sampling Event

Clam tissue sampling at the site was conducted in May 2014 in accordance with the amended quality assurance project plan (QAPP) specific to the 2014clam tissue collection. Clams were collected within the same time window (May) as in the 2003 and 2011 monitoring events. Prior to clam tissue collection, a reconnaissance survey was conducted on 29 January 2014 to determine if sufficient clams are present for tissue collection and analysis in the West Beach area since none were found at this location during the 2011 event. Based on that survey, horse clams were found in sufficient numbers on the West Beach (aka West Beach Exposure Beach System [EBS] area) and therefore were collected from this location in 2014. Sediment at the West Beach appeared to be predominantly fish mix gravels and was different from sediments found at the other sampling locations.

Clams were collected on 16 May 2014 at three separate locations within the Intertidal Cap, North Shoal, West Beach and East Beach locations (Figure 1). Clams were not collected on a grid system as the objective was to collect enough clams for tissue analysis within the separate locations. Clams were collected from the locations adjacent to those previously sampled in 2003 and 2011 to the extent practicable. The general collection sites were GPS located rather than at each specific hole from which clams were collected. A new GPS reading was taken for all sample locations on West Beach, North Shoal, East Beach, and Intertidal Cap. All clams were placed in coolers with ice in accordance with the

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[1] http://wdfw.wa.gov/fishing/shellfish/clams/horse_clams.html

[2] http://www.wallawalla.edu/academics/departments/biology/rosario/inverts/Mollusca/Bivalvia/Veneroida/Mactridae/Tresus_capax.html

QAPP and were hand delivered to Manchester Laboratory under chain of custody at the end of the collection day for analysis of PAHs and lipids.

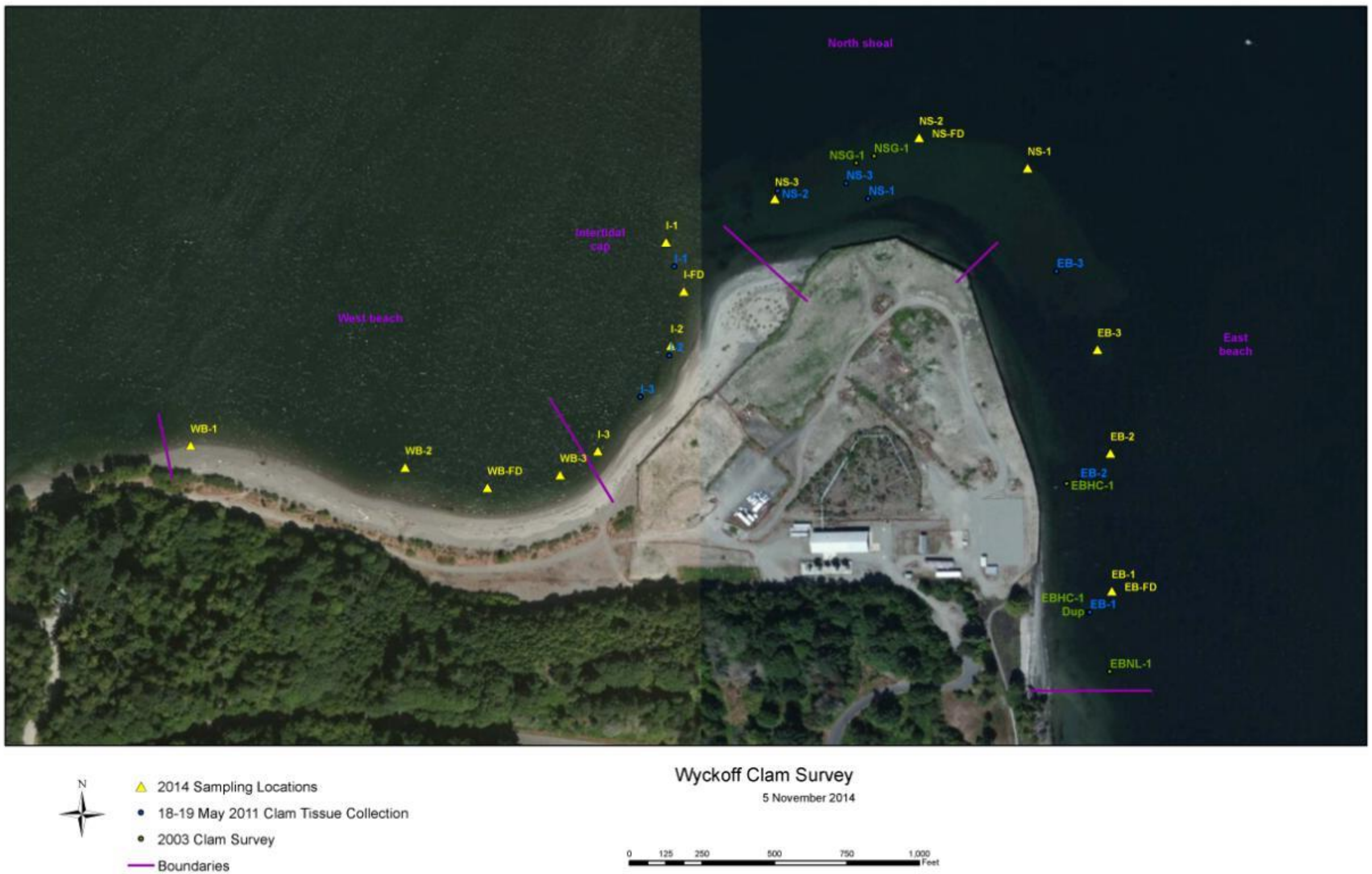

Figure 1 Wyckoff Clam Survey Locations in 2003, 2011 and May 2014

Per discussion with Richard Brooks of the Suquamish Tribe (2/17/2011), it was anticipated that only shellfish of harvestable size would be collected (the State of Washington Statewide Harvest Rules has “no minimum size” for horse clams). The goal for the sampling effort was to represent as accurately as possible the types of shellfish that would actually be harvested and therefore it was determined that clams of four inches or larger would be collected. As described in the QAPP, three clams, larger than four inches of a single species, were collected at 12 separate locations (3 each at West Beach, Intertidal Cap, North Shoal, and East Beach). A field duplicate (FD) was collected at each of the four beach locations (Figure 1). A review of the clam weights collected in 2011 determined that only three clams would be required to achieve the necessary weight for the PAH and lipid analysis.

Tresus capax clams were collected on the outgoing tide by two teams to reduce sampling time to only one day. One team collected clams from East Beach and North Shoal and the other team collected clams from West Beach and Intertidal Cap. Species identification was verified by Debbie Kay of the Suquamish Tribe. Three individual clams were collected from each station, rinsed with site seawater, placed in a labeled plastic self sealing bag, and placed on ice in the cooler in accordance with the QAPP. Three additional clams were collected within each of the primary areas for field duplicate analysis. No clams were collected within the eelgrass beds on North Shoal and East Beach. Several holes were dug to collect sufficient clams at the targeted sites. GPS locations were taken for the sampling area and not at each specific digging hole.

2.2 Differences Between the 2011 and 2014 Sampling Events

Several difference between the 2011 and 2014 sampling events are worth noting. The clams collected in 2011 and 2014 were *Tresus capax* (*Tresus nuttali* collected in 2011 were not analyzed). The species identification was confirmed in the field by Debbie Kay, a biologist with the Suquamish Tribe during both sampling events. The 2011 samples included five clams in each composite sample. In 2014, three clams were included in each composite sample as the analytical laboratory confirmed that three clams would generate a sufficient volume of tissue for analysis. Lowering the number of clams required in each composite from five to three made it easier to complete the sampling - it was not always possible to find five legal-sized clams within a reasonably small sampling area, and finding three clams was easier. The 2014 sampling included clams from West Beach. No horse clams were found on West Beach in 2011. The addition of West Beach brings a new area into the data set, where the sediment is largely fill material imported in 2008. The clams from West Beach are assumed to be no more than three years old, since they were not found in 2011. The age of the clams from the other beaches is unknown and it is possible that they are older than the clams collected from West Beach.

2.3 Tissue Data

There are no established tissue-based PAH protectiveness goals in the East Harbor Record of Decision (ROD). Instead, the ROD identifies a sediment-based human health objective of 1,200 ug/kg dry weight high-molecular weight polycyclic aromatic hydrocarbons (HPAH), which is based on the 90th percentile of background Puget Sound subtidal sediments.

Tissue samples were collected in accordance with the Puget Sound Protocols and Guidelines, *Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound* (PSAT 1997). Three clams were collected to represent a single composite sample (composited in the laboratory) and three separate composite samples were collected at each of the four separate beach areas (a field duplicate represented the fourth composite sample) for a total of 12 sample locations. Once removed from the sediment, the horse clams were rinsed in site seawater, measured, and placed in bags with a sample label. Whole clams were placed in a cooler with ice (cooled to 4^oC) and hand delivered to the laboratory where they were processed for analysis. A minimum of 100 grams of clam tissue (whole body without shell) is required in each tissue sample for analysis of PAH and lipids. This was accomplished by compositing the three clams taken from each sample location. Gutball contents were removed and discarded prior to sample compositing. Since the clams are large, the liquid inside the shell was not retained therefore, clams were not depurated prior to processing. The laboratory processing included resection of the entire clam tissue, removing the outer skin and hard tip from the neck, discarding the contents of the gutball (empty the gutball and rinse with distilled water then retain the gutball tissue for analysis), homogenizing the composite samples, and freezing the samples in glass jars at -18^oC for subsequent analysis.

PAHs. The Manchester Environmental Laboratory limit of quantitation (LOQ) for the seven carcinogenic PAHs is estimated to range from 1 to 2 parts per billion (ppb). The tissue samples were extracted using EPA Method 3550-M modified (industrial blender), cleaned up using EPA Method 3660B, 3665A, and 3640A if needed, and analyzed for PAHs using EPA Method 8270D -SIM modified as necessary to achieve the required reporting limits.

Lipids. The Manchester Environmental Laboratory Standard Operating Procedure was used for lipid content analysis. The laboratory reports the total weight for each homogenized sample which for this sampling event included skinned neck (hard tip removed), strap, and empty gutball. The tissue sample preparation and homogenization procedure was modified from the Washington Department of Health February 4, 2011 Technical Assistance for preparing geoduck tissue samples.

3.0 Results

Table 1 presents the results of the 2014 and the 2011 clam tissue samples from East Beach, North Shoal, Intertidal Beach, and West Beach (2014 only). Total cPAHs[3] for 2014 ranged from a high of 74.32 ug/kg-wet (w) at North Shoal FD (second highest was 42.75 ug/kg at North Shoal #3) to a low of 6.38 ug/kg-w at East Beach FD. Chemicals with the highest values at most locations were acenaphthene, fluoranthene, and phenanthrene. Values for cPAHs were highest at the North Shoal stations and were greater (average ~34 ug/kg) than either the East Beach (average ~7 ug/kg), Intertidal Beach (average ~8 ug/kg), or West Beach (average ~ 7 ug/kg).

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[3] For all cPAH summation calculations, non-detects were assigned a value of one-half the reporting limit.

Carcinogenic PAH (cPAH) total toxicity equivalents (TEQ) ranged from a low of 0.49 ug/kg-w at West Beach FD to a high of 8.01 ug/kg-w at North shoal FD in 2014. In 2011, the TEQ ranged from 1.61 ug/kg-w at East Beach 1 to 13.19 ug/kg at North Shoal 1.

Lipid content ranged from a high of 1.1 percent at East Beach 3 and North Shoal FD to a low of 0.36 percent at West Beach 1. Lipid normalized cPAH totals ranged from 6.76 mg/kg-w at North Shoal FD to a low of 0.69 mg/kg-w at East Beach 3. Lipid concentrations are frequently corrected for variation in tissue lipid content. This correction is accomplished by dividing tissue contaminant concentration by lipid concentrations to form lipid-normalized data and thereby having lower variability.

Table 1. 2014 and 2011 Clam Tissue PAHs from all Locations

2014 and 2011 RESULTS

Sample Location: East Beach #1

Compound	Benzo(a)pyrene TEF	2014 Result ug/kg	2014 Qualifier	2011 Results ug/kg	2011 Qualifier	2014 Lipid Normalized mg/kg	2011 Lipid Normalized mg/kg	2014 TEQ	2011 TEQ
9H-Fluorene		0.82	U	0.93	U	0.11	0.17		
Acenaphthene		0.82	U	0.93	U	0.11	0.17		
Acenaphthylene		0.82	U	0.93	U	0.11	0.17		
Anthracene		0.82	U	**4.50**		0.11	0.83		
Benz(a)anthracene*	0.1	0.82	U	**2.10**		0.11	0.39	0.041	0.21
Benzo(a)pyrene*	1	0.82	U	**1.20**		0.11	0.22	0.41	1.2
Benzo(g,h,i)perylene		0.82	U	**5.70**		0.11	1.06		
Benzo[b]fluoranthene*	0.1	**1.1**		0.93	U	0.15	0.17	0.11	0.0465
Benzo[k]fluoranthene*	0.01	0.82	U	0.93	U	0.11	0.17	0.0041	0.00465
Chrysene*	0.01	**1.4**		1.9	U	0.19	0.35	0.014	0.0095
Dibenz[a,h]anthracene*	0.1	0.82	U	0.93	U	0.11	0.17	0.041	0.0465
Fluoranthene		**3.7**		**3.9**		0.50	0.72		
Indeno(1,2,3-cd)pyrene*	0.1	0.82	U	1.90	U	0.11	0.35	0.041	0.095
Naphthalene		2.60	U	1.10	U	0.35	0.20		
Naphthalene, 1-methyl-		**3.9**				0.53	0.00		
Naphthalene, 2-methyl-		**9**		1.4	U	1.22	0.26		
Phenanthrene		**2**		**3.3**		0.27	0.61		
Pyrene		**5**		**4.8**		0.68	0.89		
Total cPAH, 0.5*RL								0.66	1.61
Lipid %		0.74%		0.54%					
Total cPAH, lipid mg/kg						0.89	1.83		
Total cPAH ug/kg		6.60		9.89					
* = cPAHs									

Sample Location: East Beach #2

Compound	2014 Result ug/kg	2014 Qualifier	2011 Results ug/kg	2011 Qualifier	2014 Lipid Normalized mg/kg	2011 Lipid Normalized mg/kg	2014 TEQ	2011 TEQ
9H-Fluorene	**1.2**		**1.60**		0.17	0.33		
Acenaphthene	**1.2**		**1.60**		0.17	0.33		
Acenaphthylene	0.8	U	0.93	U	0.11	0.19		
Anthracene	0.8	U	**4.30**		0.11	0.88		
Benz(a)anthracene*	**1**		**3.00**		0.14	0.61	0.1	0.3
Benzo(a)pyrene*	0.8	U	**1.60**		0.11	0.33	0.4	1.6
Benzo(g,h,i)perylene	0.8	U	**5.10**		0.11	1.04		
Benzo[b]fluoranthene*	**1.7**		**1.7**		0.24	0.35	0.17	0.17
Benzo[k]fluoranthene*	**0.82**		0.93	U	0.11	0.19	0.0082	0.00465
Chrysene*	**3.2**		1.9	U	0.44	0.39	0.032	0.0095
Dibenz[a,h]anthracene*	0.8	U	0.93	U	0.11	0.19	0.04	0.0465
Fluoranthene	**6.7**		**7.6**		0.93	1.55		
Indeno(1,2,3-cd)pyrene*	0.8	U	1.90	U	0.11	0.39	0.04	0.095
Naphthalene	2.6	U	1.40	U	0.36	0.29		
Naphthalene, 1-methyl-	**3.3**				0.46	0.00		
Naphthalene, 2-methyl-	**7.1**		1.3	U	0.99	0.27		
Phenanthrene	**4.1**		**6.7**		0.57	1.37		
Pyrene	**15**		**11**		2.08	2.24		
Total cPAH, 0.5*RL							0.79	2.23
Lipid %	0.72%		0.49%					
Total cPAH, lipid mg/kg					1.27	2.44		
Total cPAH ug/kg	9.12		11.96					

Sample Location: East Beach #3

Compound	2014 Result ug/kg	2014 Qualifier	2011 Results ug/kg	2011 Qualifier	2014 Lipid Normalized mg/kg	2011 Lipid Normalized mg/kg	2014 TEQ	2011 TEQ
9H-Fluorene	**1.2**		**1.10**		0.11	0.28		
Acenaphthene	**0.88**		**1.00**		0.08	0.25		
Acenaphthylene	0.84	U	0.95	U	0.08	0.24		
Anthracene	0.84	U	**5.20**		0.08	1.30		
Benz(a)anthracene*	0.84	U	**2.90**		0.08	0.73	0.042	2.378
Benzo(a)pyrene*	0.84	U	**1.90**		0.08	0.48	0.42	1.558
Benzo(g,h,i)perylene	0.84	U	**6.00**		0.08	1.50		
Benzo[b]fluoranthene*	**1.2**		**1.9**		0.11	0.48	0.12	2.09
Benzo[k]fluoranthene*	0.84	U	0.95	U	0.08	0.24	0.0042	0.00475
Chrysene*	**2.2**		1.9	U	0.20	0.48	0.022	0.0095
Dibenz[a,h]anthracene*	0.84	U	0.95	U	0.08	0.24	0.042	0.0475
Fluoranthene	**6.6**		**5.2**		0.60	1.30		
Indeno(1,2,3-cd)pyrene*	0.84	U	1.90	U	0.08	0.48	0.042	0.095
Naphthalene	2.7	U	1.50	U	0.25	0.38		
Naphthalene, 1-methyl-	**4.1**				0.37	0.00		
Naphthalene, 2-methyl-	**9**		**1.6**	U	0.82	0.40		
Phenanthrene	**4**		**4.7**		0.36	1.18		
Pyrene	**8.4**		**26**		0.76	6.50		
Total cPAH, 0.5*RL							0.69	6.18
Lipid %	1.10%		0.40%					
Total cPAH, lipid mg/kg					0.69	3.10		
Total cPAH ug/kg	7.60		12.40					

Sample Location: East Beach #FD

Compound	2014 Result ug/kg	2014 Qualifier	2014 Lipid Normalized mg/kg	2014 TEQ
9H-Fluorene	0.83	U	0.11	
Acenaphthene	0.83	U	0.11	
Acenaphthylene	0.83	U	0.11	
Anthracene	0.83	U	0.11	
Benz(a)anthracene*	0.83	U	0.11	0.0415
Benzo(a)pyrene*	0.83	U	0.11	0.415
Benzo(g,h,i)perylene	0.83	U	0.11	
Benzo[b]fluoranthene*	0.83	U	0.11	0.0415
Benzo[k]fluoranthene*	0.83	U	0.11	0.00415
Chrysene*	**1.4**		0.18	0.014
Dibenz[a,h]anthracene*	0.83	U	0.11	0.0415
Fluoranthene	**3.1**		0.40	
Indeno(1,2,3-cd)pyrene*	0.83	U	0.11	0.0415
Naphthalene	2.7	U	0.35	
Naphthalene, 1-methyl-	2.4	U	0.31	
Naphthalene, 2-methyl-	**5**		0.64	
Phenanthrene	**1.7**		0.22	
Pyrene	**4.2**		0.54	
Total cPAH, 0.5*RL				0.60
Lipid %	0.78%			
Total cPAH, lipid mg/kg			0.82	
Total cPAH ug/kg	6.38			

nd=0.5*RL: cPAHs calcualted using one half of the reporting limit for all non-detect values

2011 FD were only collected at North Shoal and Intertidal Cap; no clams were found at West Beach

BOLD indicate detected values

TEQ = tissue concentration * TEF for detected concentrations and = tissue concentration*0.5*TEF for non-detects

Compound	Benzo(a)pyrene TEF	North Shoal #1 2014 Result ug/kg	2014 Qualifier	2011 Results ug/kg	2011 Qualifier	2014 Lipid Normalized mg/kg	2011 Lipid Normalized mg/kg	2014 TEQ	2011 TEQ
9H-Fluorene		**1.3**		**1.70**		0.19	0.30		
Acenaphthene		**1.2**		**1.20**		0.18	0.21		
Acenaphthylene		0.85	U	**1.40**		0.13	0.25		
Anthracene		**0.88**		**10.00**		0.13	1.79		
Benz(a)anthracene*	0.1	**0.96**		**2.80**		0.14	0.50	0.096	2.296
Benzo(a)pyrene*	1	0.85	U	**3.40**		0.13	0.61	0.425	2.788
Benzo(g,h,i)perylene		0.85	U	**5.80**		0.13	1.04		
Benzo[b]fluoranthene*	0.1	**2.3**		**4.2**		0.34	0.75	0.23	4.62
Benzo[k]fluoranthene*	0.01	**0.97**		**1.20**		0.14	0.21	0.0097	0.984
Chrysene*	0.01	**3.2**		1.9	U	0.47	0.34	0.032	1.33
Dibenz[a,h]anthracene*	0.1	0.85	U	0.95	U	0.13	0.17	0.0425	0.3895
Fluoranthene		**8.2**		**11**		1.21	1.96		
Indeno(1,2,3-cd)pyrene*	0.1	0.85	U	1.90	U	0.13	0.34	0.0425	0.779
Naphthalene		2.8	U	1.80	U	0.41	0.32		
Naphthalene, 1-methyl-		2	U			0.29	0.00		
Naphthalene, 2-methyl-		**4.3**		1	U	0.63	0.18		
Phenanthrene		**5.9**		**6.4**		0.87	1.14		
Pyrene		**11**		**24**		1.62	4.29		
Total cPAH, 0.5*RL								0.88	13.19
Lipid %		0.68%		0.56%					
Total cPAH, lipid mg/kg						1.47	2.92		
Total cPAH ug/kg		9.98		16.35					

Compound	North Shoal #2 2014 Result ug/kg	2014 Qualifier	2011 Results ug/kg	2011 Qualifier	2014 Lipid Normalized mg/kg	2011 Lipid Normalized mg/kg	2014 TEQ	2011 TEQ
9H-Fluorene	**1.2**		**1.50**		0.18	0.28		
Acenaphthene	**0.92**		**1.40**		0.14	0.26		
Acenaphthylene	0.82	U	**1.20**		0.12	0.23		
Anthracene	0.82	U	**9.90**		0.12	1.87		
Benz(a)anthracene*	**0.97**		**3.50**		0.14	0.66	0.097	2.87
Benzo(a)pyrene*	0.82	U	**3.00**		0.12	0.57	0.41	2.46
Benzo(g,h,i)perylene	0.82	U	**5.20**		0.12	0.98		
Benzo[b]fluoranthene*	**1.5**		**3.3**		0.22	0.62	0.15	3.63
Benzo[k]fluoranthene*	**0.82**		**1.10**		0.12	0.21	0.0082	0.902
Chrysene*	**3.5**		1.8	U	0.52	0.34	0.035	1.26
Dibenz[a,h]anthracene*	0.82	U	0.91	U	0.12	0.17	0.041	0.3731
Fluoranthene	**8.6**		**15**		1.28	2.83		
Indeno(1,2,3-cd)pyrene*	0.82	U	1.80	U	0.12	0.34	0.041	0.738
Naphthalene	2.6	U	2.10	U	0.39	0.40		
Naphthalene, 1-methyl-	2.4	U			0.36	0.00		
Naphthalene, 2-methyl-	**5**		1	U	0.75	0.19		
Phenanthrene	**6.5**		**6.7**		0.97	1.26		
Pyrene	**10**		**26**		1.49	4.91		
Total cPAH, 0.5*RL							0.78	12.23
Lipid %	0.67%		0.53%					
Total cPAH, lipid mg/kg					1.38	2.91		
Total cPAH ug/kg	9.25		15.41					

Compound	North Shoal #3 2014 Result ug/kg	2014 Qualifier	2011 Results ug/kg	2011 Qualifier	2014 Lipid Normalized mg/kg	2011 Lipid Normalized mg/kg	2014 TEQ	2011 TEQ
9H-Fluorene	**4.1**		**9.00**		0.51	1.88		
Acenaphthene	**5.9**		**1.50**		0.74	0.31		
Acenaphthylene	0.85	U	**1.30**		0.11	0.27		
Anthracene	**6.8**		**11.00**		0.85	2.29		
Benz(a)anthracene*	**8.7**		**2.60**		1.09	0.54	0.87	2.132
Benzo(a)pyrene*	**3.7**		**2.30**		0.46	0.48	3.7	1.886
Benzo(g,h,i)perylene	0.85	U	**4.30**		0.11	0.90		
Benzo[b]fluoranthene*	**9.3**		**2.9**		1.16	0.60	0.93	3.19
Benzo[k]fluoranthene*	**3.1**		**1.40**		0.39	0.29	0.031	1.148
Chrysene*	**16**		1.9	U	2.00	0.40	0.16	1.33
Dibenz[a,h]anthracene*	0.85	U	0.94	U	0.11	0.20	0.0425	0.385
Fluoranthene	**76**		**9**		9.50	1.88		
Indeno(1,2,3-cd)pyrene*	**1.1**		1.90	U	0.14	0.40	0.11	0.779
Naphthalene	3.2	U	2.00	U	0.40	0.42		
Naphthalene, 1-methyl-	**4.3**				0.54	0.00		
Naphthalene, 2-methyl-	**8.1**		1.6	U	1.01	0.33		
Phenanthrene	**16**		**7**		2.00	1.46		
Pyrene	**130**		**14**		16.25	2.92		
Total cPAH, 0.5*RL							5.84	10.85
Lipid %	0.80%		0.48%					
Total cPAH, lipid mg/kg					5.34	2.90		
Total cPAH ug/kg	42.75		13.94					

Compound	North Shoal #FD 2014 Result ug/kg	2014 Qualifier	2011 Results ug/kg	2011 Qualifier	2014 Lipid Normalized mg/kg	2011 Lipid Normalized mg/kg	2014 TEQ	2011 TEQ
9H-Fluorene	**180**		**1.60**		16.36	0.27		
Acenaphthene	**260**		**1.20**		23.64	0.20		
Acenaphthylene	**2.2**		0.95	U	0.20	0.16		
Anthracene	**65**		**5.30**		5.91	0.88		
Benz(a)anthracene*	**25**		**2.00**		2.27	0.33	2.5	1.64
Benzo(a)pyrene*	**4**		**1.40**		0.36	0.23	4	1.148
Benzo(g,h,i)perylene	0.86	U	**4.30**		0.08	0.72		
Benzo[b]fluoranthene*	**11**		**2**		1.00	0.33	1.1	2.2
Benzo[k]fluoranthene*	**2.6**		0.95	U	0.24	0.16	0.026	0.3895
Chrysene*	**30**		1.9	U	2.73	0.32	0.3	1.33
Dibenz[a,h]anthracene*	0.86	U	0.95	U	0.08	0.16	0.043	0.3895
Fluoranthene	**200**		**7.5**		18.18	1.25		
Indeno(1,2,3-cd)pyrene*	0.86	U	1.90	U	0.08	0.32	0.043	0.779
Naphthalene	**160**		1.40	U	14.55	0.23		
Naphthalene, 1-methyl-	**180**				16.36	0.00		
Naphthalene, 2-methyl-	**16**		**3.5**		1.45	0.58		
Phenanthrene	**500**		**6**		45.45	1.00		
Pyrene	**160**		**13**		14.55	2.17		
Total cPAH, 0.5*RL							8.01	7.88
Lipid %	1.10%		0.60%					
Total cPAH, lipid mg/kg					6.76	1.85		
Total cPAH ug/kg	74.32		11.10					

* = cPAHs

nd=0.5*RL: cPAHs calculated using one half of the reporting limit for all non-detect values
2011 FD were only collected at North Shoal and
Intertidal Cap; no clams were found at West Beach

Sample Location		Intertidal Beach #1								Intertidal Beach #2								Intertidal Beach #3								Intertidal Beach #FD							
Compound	Benzo(a)pyrene TEF	2014 Result ug/kg	Qualifier	2011 Results ug/kg	2011 Qualifier	2014 Lipid Normalized mg/kg	2011 Lipid Normalized mg/kg	2014 TEQ	2011 TEQ	2014 Result ug/kg	2014 Qualifier	2011 Results ug/kg	2011 Qualifier	2014 Lipid Normalized mg/kg	2011 Lipid Normalized mg/kg	2014 TEQ	2011 TEQ	2014 Result ug/kg	2014 Qualifier	2011 Results ug/kg	2011 Qualifier	Lipid Normalized mg/kg	2011 Lipid Normalized mg/kg	2014 TEQ	2011 TEQ	2014 Result ug/kg	2014 Qualifier	2011 Results ug/kg	2011 Qualifier	2014 Lipid Normalized mg/kg	2011 Lipid Normalized mg/kg	2014 TEQ	2011 TEQ
9H-Fluorene		**1.6**		**1.20**		0.21	0.26			**0.91**		**1.20**		0.15	0.22			0.81	U	**1.40**		0.17	0.20			0.88	U	**1.00**		0.20	0.19		
Acenaphthene		**1.4**		**0.99**		0.18	0.21			0.85	U	0.93	U	0.14	0.17			0.81	U	**0.99**		0.17	0.14			0.88	U	0.92	U	0.20	0.18		
Acenaphthylene		0.83	U	**1.20**		0.11	0.26			0.85	U	**1.10**		0.14	0.20			0.81	U	**1.60**		0.17	0.23			0.88	U	**1.00**		0.20	0.19		
Anthracene		0.83	U	**9.60**		0.11	2.04			0.85	U	**10.00**		0.14	1.82			0.81	U	**17.00**		0.17	2.39			**1.7**		**10.00**		0.40	1.92		
Benz(a)anthracene*	0.1	0.83	U	**2.40**		0.11	0.51	0.0415	1.968	0.85	U	**2.20**		0.14	0.40	0.0425	1.804	0.81	U	**3.40**		0.17	0.48	0.0405	2.788	0.88	U	**1.80**		0.20	0.35	0.044	1.476
Benzo(a)pyrene*	1	0.83	U	**1.30**		0.11	0.28	0.415	1.066	0.85	U	**1.10**		0.14	0.20	0.425	0.902	0.81	U	**1.50**		0.17	0.21	0.405	1.23	0.88	U	**1.20**		0.20	0.23	0.44	0.984
Benzo(g,h,i)perylene		0.83	U	**5.10**		0.11	1.09			0.85	U	**6.8**		0.14	1.24			0.81	U	**6.20**		0.17	0.87			0.88	U	**6.30**		0.20	1.21		
Benzo[b]fluoranthene*	0.1	**1.4**		**2.2**		0.18	0.47	0.14	2.42	**1.1**		**1.8**		0.19	0.33	0.11	1.98	**1.1**		**2.6**		0.23	0.37	0.11	2.86	**1.4**		**1.7**		0.33	0.33	0.14	1.87
Benzo[k]fluoranthene*	0.01	0.83	U	0.92	U	0.11	0.20	0.00415	0.3772	0.85	U	0.93	U	0.14	0.17	0.00425	0.3813	0.81	U	0.95	U	0.17	0.13	0.0041	0.3895	0.88	U	0.92	U	0.20	0.18	0.0044	0.3772
Chrysene*	0.01	**3.5**		1.8	U	0.45	0.38	0.035	1.26	**2.4**		1.9	U	0.41	0.35	0.024	1.33	**1.6**		1.9	U	0.34	0.27	0.008	1.33	**2.6**		1.9	U	0.60	0.37	0.026	1.33
Dibenz[a,h]anthracene*	0.1	0.83	U	0.92	U	0.11	0.20	0.0415	0.3772	0.85	U	0.93	U	0.14	0.17	0.0425	0.3813	0.81	U	0.95	U	0.17	0.13	0.0405	0.3895	0.88	U	0.92	U	0.20	0.18	0.044	0.3772
Fluoranthene		**9.6**		**7.3**		1.23	1.55			**6.5**		**7.3**		1.10	1.33			**2.7**		**7.3**		0.57	1.03			**6.6**		**6.4**		1.53	1.23		
Indeno(1,2,3-cd)pyrene*	0.1	0.83	U	1.80	U	0.11	0.38	0.0415	0.738	0.85	U	1.90	U	0.14	0.35	0.0425	0.779	0.81	U	1.90	U	0.17	0.27	0.0405	0.779	0.88	U	1.90	U	0.20	0.37	0.044	0.779
Naphthalene		2.7	U	1.10	U	0.35	0.23			2.7	U	0.93	U	0.46	0.17			2.6	U	1.30	U	0.55	0.18			2.8	U	1.00	U	0.65	0.19		
Naphthalene, 1-methyl-		1.7	U			0.22	0.00			1.1	U			0.19	0.00			1.2	U			0.26	0.00			1.6	U			0.37	0.00		
Naphthalene, 2-methyl-		3.5	U	1.5	U	0.45	0.32			2	U	13	U	0.34	2.36			2.8	U	1.7	U	0.60	0.24			2.9	U	1.2	U	0.67	0.23		
Phenanthrene		**6.6**		**4.8**		0.85	1.02			**4.1**		**5.2**		0.69	0.95			**1.9**		**4.5**		0.40	0.63			**4.7**		**4.5**		1.09	0.87		
Pyrene		**13**		**11**		1.67	2.34			**8.5**		**7.1**		1.44	1.29			**4.4**		**9.7**		0.94	1.37			**8.9**		**8.3**		2.07	1.60		
Total cPAH, 0.5*RL								0.72	8.21							0.69	7.56							0.65	9.77							0.74	7.19
Lipid %		0.78%		0.47%						0.59%		0.55%						0.47%		0.71%						0.43%		0.52%					
Total cPAH, lipid mg/kg						1.16	2.41							1.31	1.96							1.44	1.86							1.95	1.99		
Total cPAH ug/kg		9.05		11.34						7.75		10.76						6.75		13.20						8.40		10.34					

* = cPAHs

nd=0.5*RL: cPAHs calcualted using one half of the reporting limit for all non-detect values

Sample Location		West Beach #1				West Beach #2				West Beach #3				West Beach #FD				East Beach Sheen			
Compound	Benzo(a)pyrene TEF	2014 Result ug/kg	Lipid Normalized mg/kg	Qualifier	2014 TEQ	2014 Result ug/kg	Lipid Normalized mg/kg	Qualifier	2014 TEQ	2014 Result ug/kg	Lipid Normalized mg/kg	Qualifier	2014 TEQ	2014 Result ug/kg	Lipid Normalized mg/kg	Qualifier	2014 TEQ	2014 Result ug/kg	Lipid Normalized mg/kg	Qualifier	2014 TEQ
9H-Fluorene		0.83	0.23	U		0.84	0.20	U		0.8	0.18	U		**0.84**	0.14			**1.2**	0.24		
Acenaphthene		0.83	0.23	U		0.84	0.20	U		0.8	0.18	U		0.75	0.12	U		**1.1**	0.22		
Acenaphthylene		0.83	0.23	U		0.84	0.20	U		0.8	0.18	U		0.75	0.12	U		0.82	0.16	U	
Anthracene		0.83	0.23	U		0.84	0.20	U		0.8	0.18	U		0.75	0.12	U		0.82	0.16	U	
Benz(a)anthracene*	0.1	0.83	0.23	U	0.0415	0.84	0.20	U	0.042	0.8	0.18	U	0.04	0.75	0.12	U	0.0375	0.82	0.16	U	0.041
Benzo(a)pyrene*	1	0.83	0.23	U	0.415	0.84	0.20	U	0.42	0.8	0.18	U	0.4	0.75	0.12	U	0.375	0.82	0.16	U	0.41
Benzo(g,h,i)perylene		0.83	0.23	U		0.84	0.20	U		0.8	0.18	U		0.75	0.12	U		0.82	0.16	U	
Benzo[b]fluoranthene*	0.1	**1.1**	0.31		0.11	**0.99**	0.24		0.099	**0.96**	0.22		0.096	**1.1**	0.18			0.82	0.16	U	0.041
Benzo[k]fluoranthene*	0.01	0.83	0.23	U	0.00415	0.84	0.20	U	0.0042	0.8	0.18	U	0.004	0.75	0.12	U	0.00375	0.82	0.16	U	0.0041
Chrysene*	0.01	**1.7**	0.47		0.017	**1.8**	0.43		0.018	**1.8**	0.41		0.018	**2.2**	0.35			**1.5**	0.30		
Dibenz[a,h]anthracene*	0.1	0.83	0.23	U	0.0415	0.84	0.20	U	0.042	0.8	0.18	U	0.04	0.75	0.12	U	0.0375	0.82	0.16	U	0.041
Fluoranthene		**4.9**	1.36			**3.3**	0.79			**3.9**	0.89			**5.9**	0.95			**5.4**	1.08		
Indeno(1,2,3-cd)pyrene*	0.1	0.83	0.23	U	0.0415	0.84	0.20	U	0.042	0.8	0.18	U	0.04	0.75	0.12	U	0.0375	0.82	0.16	U	0.041
Naphthalene		2.7	0.75	U		2.7	0.64	U		2.6	0.59	U		2.8	0.45	U		2.6	0.52	U	
Naphthalene, 1-methyl-		1.6	0.44	U		1	0.24	U		1.7	0.39	U		1.5	0.24	U		1.7	0.34	U	
Naphthalene, 2-methyl-		3.4	0.94	U		2.3	0.55	U		3.5	0.80	U		2.1	0.34	U		3	0.60	U	
Phenanthrene		**3**	0.83			**2.2**	0.52			**2.6**	0.59			**3.4**	0.55			**4.8**	0.96		
Pyrene		**4.9**	1.36			**5.1**	1.21			**4.5**	1.02			**6.6**	1.06			**9.4**	1.88		
Total cPAH, 0.5*RL					0.67				0.67				0.64				0.49				0.58
Lipid %		0.36%				0.42%				0.44%				0.62%				0.50%			
Total cPAH, lipid mg/kg			1.93				1.66				1.54				1.14				1.28		
Total cPAH ug/kg		6.95				6.99				6.76				7.05				6.42			

* = cPAHs

nd=0.5*RL: cPAHs calcualted using one half of the reporting limit for all non-detect values

BOLD indicate detected values

4.0 Discussion and Conclusion

As stated previously, there are no established tissue-based PAH protectiveness goals in the Eagle Harbor East Beach OU Record of Decision. To account for how compounds vary in toxicity, EPA calculates weighted values called toxic equivalents (TEQs) from the individual mass quantity data reported by facilities and the associated Toxic Equivalency Factors (TEFs). The TEQs from these results can be used to facilitate a human health risk assessment.

Non-urban Puget Sound tissue background cPAH concentrations for shellfish (butter, littleneck, and goeduck, clams) were obtained from Appendix B in the Lower Duwamish EPA FFS (Aecom 2012). The mean concentration of the background data set is approximately 0.3 ug/kg-w as B(a)P TEF (0.3 ug TEQ/kg wet weight). The upper 95th confidence limit on the mean (UCL95) of the background data set is 0.839 µg TEQ/kg wet weight. By comparison, the cPAH UCL95 of the 2014 site data is 3.64 µg TEQ/kg-w and 9.90 ug TEQ/kg-w for 2011 (both calculated using the 0.5*RL method of summation). Concentrations from the Wyckoff site in 2014 were about four times higher than background.

Using EPA's ProUCL software, a statistical comparison was performed using the 2011 and 2014 total TEQs from the sample locations to determine if the site population data from 2011 and 2014 are significantly different (see Figure 5 for TEQ concentrations by location). Section 2.2 discusses the differences between the two data sets. A quantile-quantile (Q-Q) plot was prepared to graphically compare the 2011 total TEQ distribution to the 2014 distribution. The Q-Q plot is a graphical technique for determining if two data sets come from populations with a common distribution. If the two distributions being compared are similar, the points in the Q–Q plot will approximately lie on the 45^{o} line y = x. If the two sets come from a population with the same distribution, the points should fall approximately along this reference line. The greater the departure from this reference line, the greater the evidence for the conclusion that the two data sets have come from populations with different distributions. The "probability plot correlation coefficient" is the correlation coefficient between the paired sample quantiles. The closer the correlation coefficient is to one, the closer the distributions are to being shifted, scaled versions of each other. While not quantitative, Q-Q plots can provide useful qualitative visual information when comparing distributions. Figure 2 shows the Q-Q plot for the 2014 and 2011 sum cPAH TEQ ug/kg-w. As can be seen below, the slope, intercept, and correlation are different when comparing 2014 to 2011 tissue concentration values.

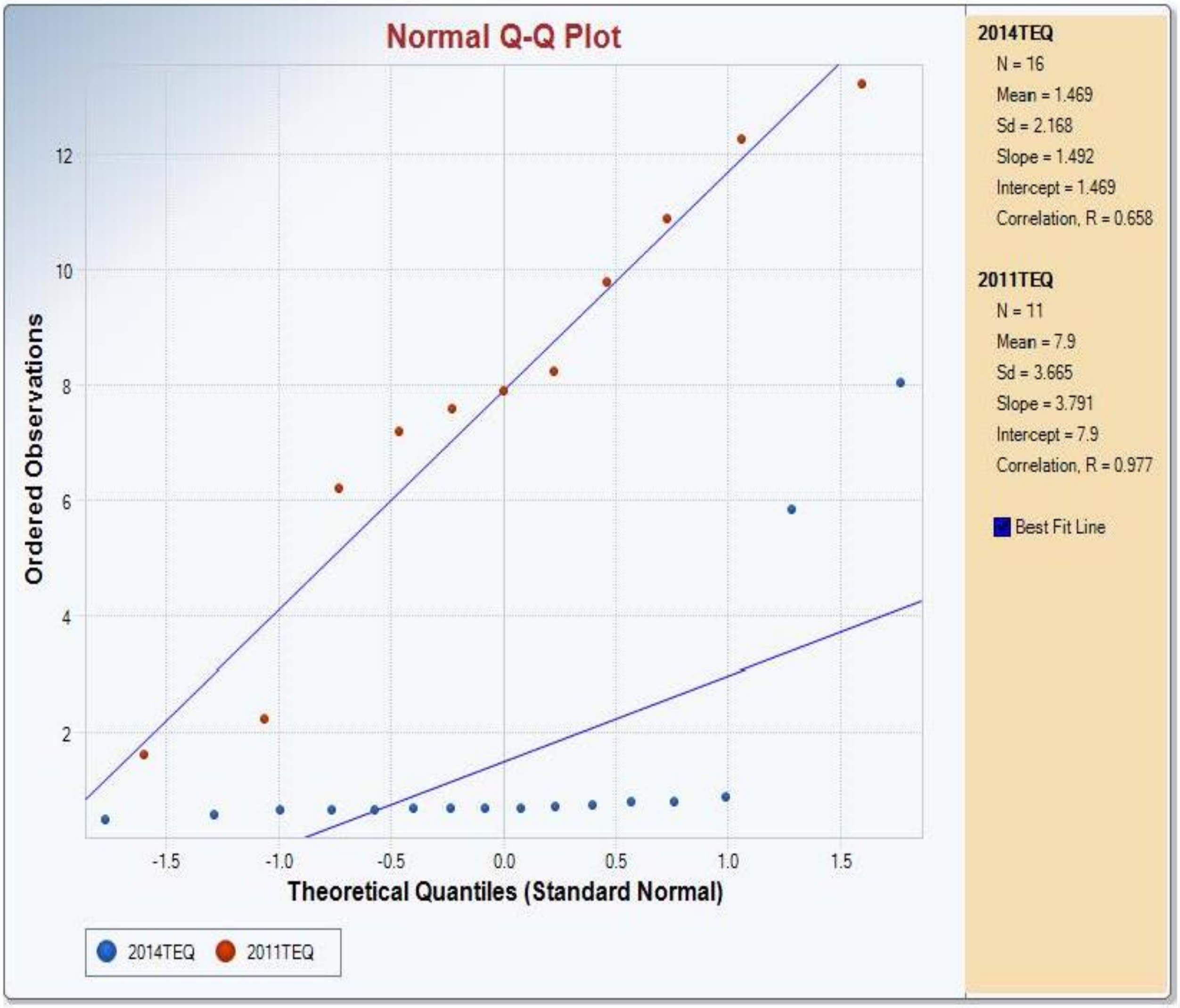

Figure 2 Best fit line of 2014 and 2011 TEQ values

Total cPAH, 0.5*RL TEQ in 2014 ranged from a low of 0.49 ug/kg-w at West Beach FD to a high of 8.01 ug/kg-w at North Shoal FD (see Figure 1 for locations). Total cPAH, 0.5*RL TEQ in 2011 ranged from a low of 1.61 ug/kg-w at East Beach 1 to a high of 13.19 ug/kg-w at North Shoal 1. Figure 3 and Figure 4 show a comparison of 2014 and 2011 sum cPAH TEQ and cPAH values respectively. Figure 3 shows that the sum cPAH TEQ ug/kg-w between 2014 and 2011 are significantly different as there is no overlap. The same is shown in Figure 4 for sum cPAH between 2014 and 2011. Figure 5 shows the sum cPAH TEQs by location for both 2014 and 2011.

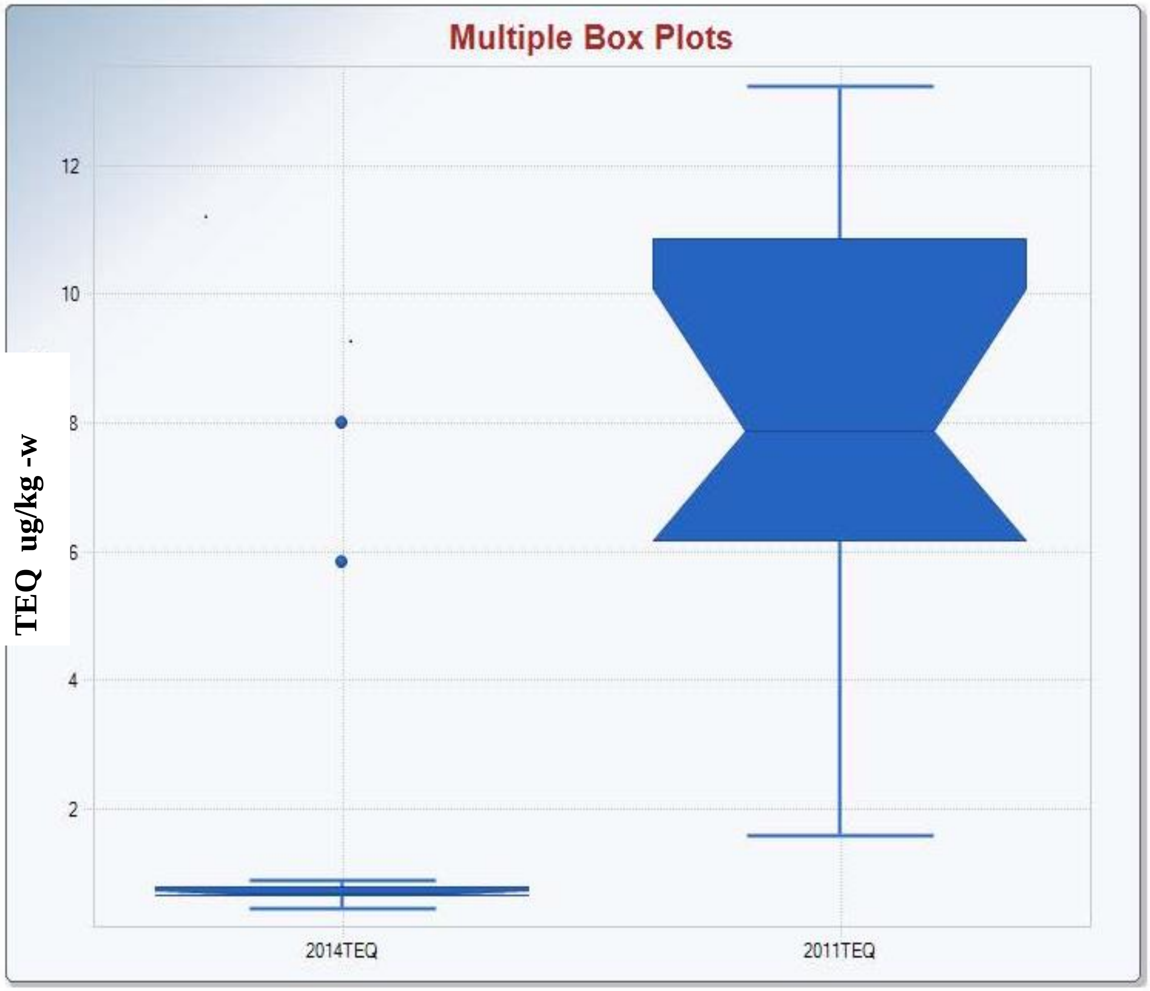

Figure 3 Multiple Box Plots of 2014 and 2011 TEQ ug/kg-w

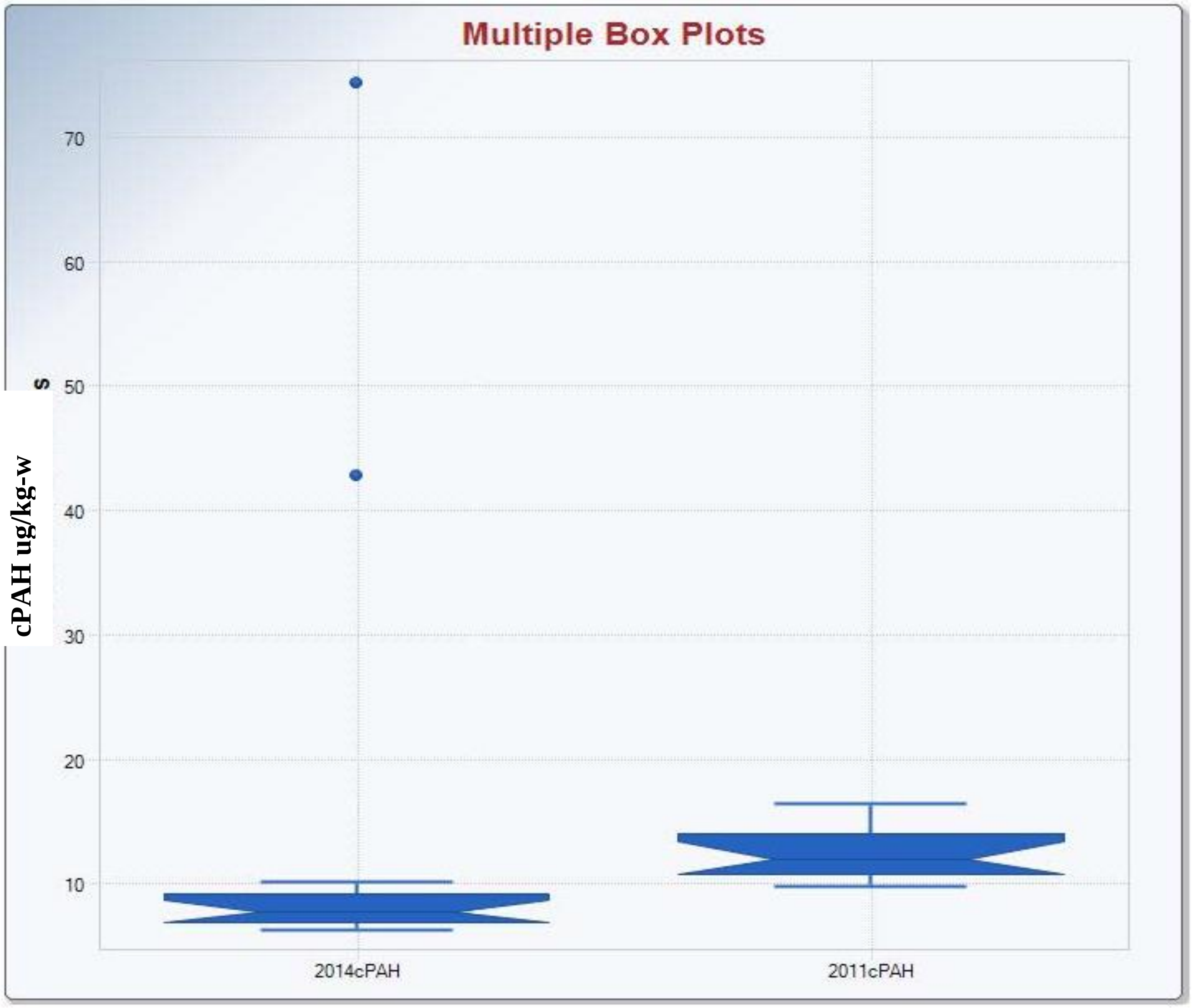

Figure 4 Multiple Box Plots of 2014 and 2011 cPAH ug/kg

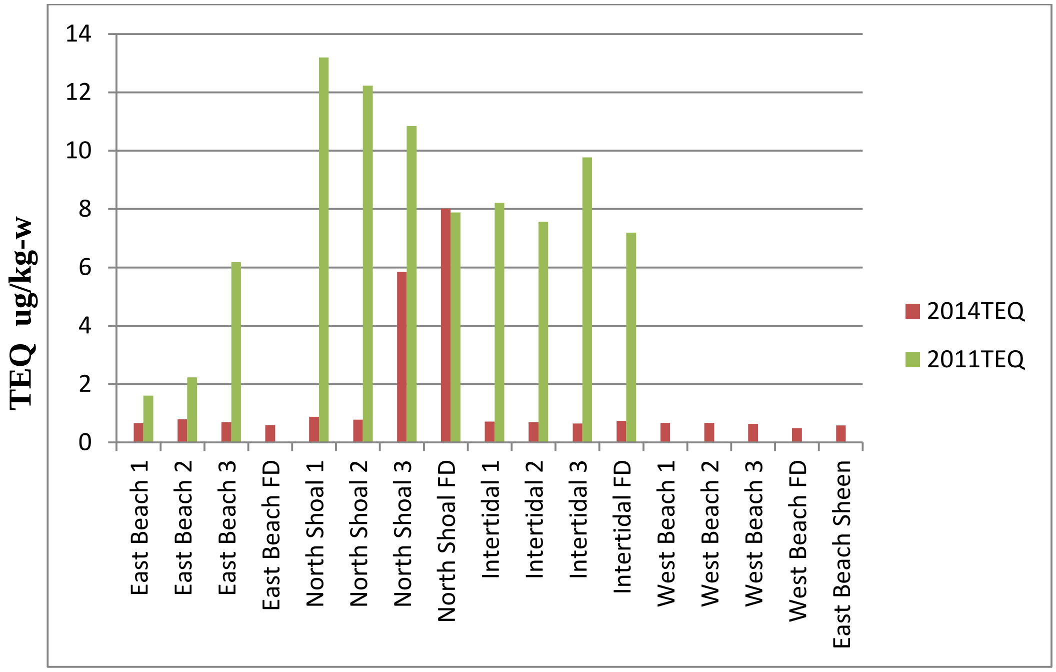

Figure 5 Graph of 2014 and 2011 sum TEQ ug/kg-w by location

A two sample hypothesis t-Test of the 2014 to 2011 sum cPAH TEQ ug/kg-w found that the 2014 sum cPAH TEQ ug/kg-w were significantly less than the 2011 sum cPAH TEQ ug/kg-w (p = 0.065). In addition, a Wilcoxon-Mann-Whitney hypothesis test analysis found that the 2014 sum cPAH TEQ ug/kg-w were less than the 2011 sum cPAH TEQ ug/kg-w at an Alpha = 0.05. Refer to Figure 3 for a box plot displaying the TEQ differences between 2014 and 2011.

cPAH vs. Lipid

A comparison of the cPAH ug/kg (0.5*RL) to the lipid fraction found no correlation (R value of 0.59, p = 0.02 for 2014) (R value of 0.08, p = 0.8 for 2011) in either the 2014 or 2011 data (Figure 6 and Figure 7).The 74.32 ug/kg cPAH is an outlier and the R slope without this value is 0.26. A R value shows correlation when its value approaches 1 and no correlation as the value approaches 0. Since cPAH concentrations in the tissue are not related to lipid tissue concentration, when the clams are collected does not result in changes in the cPAH concentrations in the horse clam tissues. In addition, a study of the clam *Macoma balthica* found that “a release of lipid-rich gametes by *M. balthica* has a limited impact on lipid accumulation (and level in the whole body) due to a low share of gonad lipids in lipid resources of the whole body (up to 15%). Similarly, the process of intensive gametogenesis in early summer is not coincident with the increase of lipid content in the whole body” (Wenne and Polak 1992).

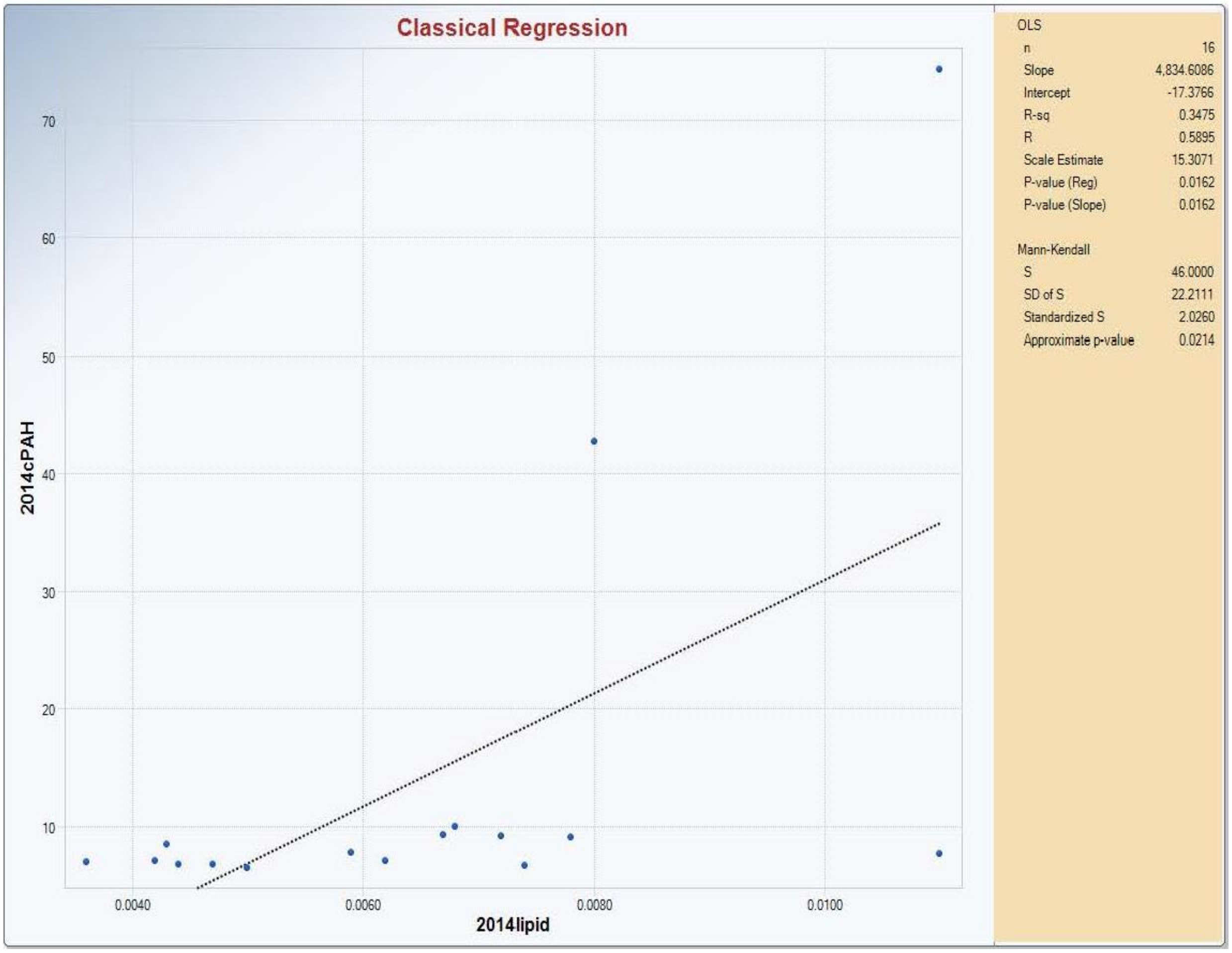

Figure 6 Ordinary Least Squares Regression of 2014 cPAH vs. lipid fraction

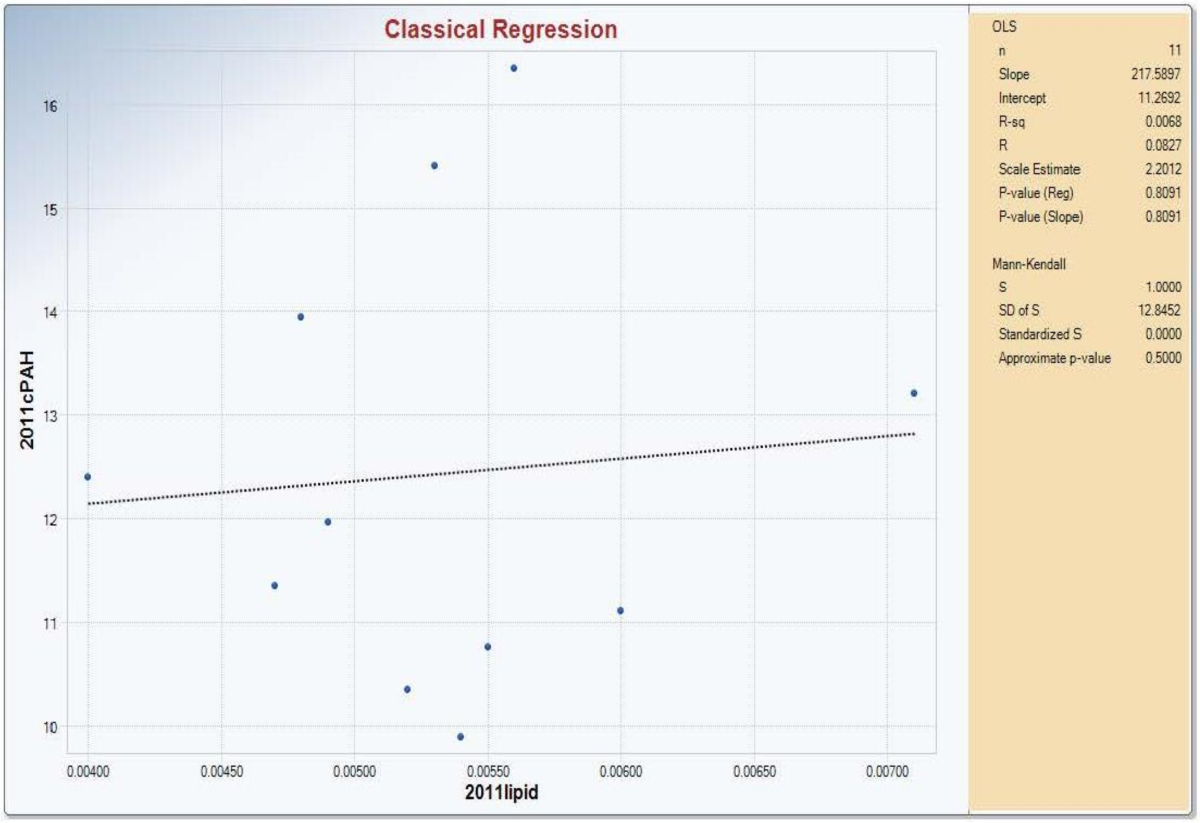

Figure 7 Ordinary Least Squares Regression of 2011 cPAH vs. lipid fraction

Based on the data analysis, natural recovery is reducing cPAH tissue concentrations when comparing sum cPAH TEQ ug/kg-w 2011 concentrations (total sum = 86.9 TEQ ug/kg-w) to 2014 sum cPAH TEQ ug/kg-w concentrations (total sum = 23.5 TEQ ug/kg-w) which includes four additional sample locations (Figure 3).

5.0 References

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